Phenomena of Vision.

Your correspondent, Mr. W. Betz, refers in his letter of May 7 to the fact that an object just screened from direct vision by the nose (or by any other obstruction) becomes visible if we rotate the eye in a direction away from the object. This is a well-known phenomenon, and a very interesting one on account of the curious facts with regard to vision that can be deduced from it; but it is not in any way due to spherical aberration. It is rather a perspective effect, being caused simply by the shifting of the point of sight, which, being situated near the crystalline lens, moves laterally as the eye is rotated about its centre. There are several ways of demonstrating the movement of the point of sight, but the experiment described by Mr. Betz is perhaps the most convincing.

An interesting corollary of this experiment is the generally unfamiliar fact that we employ two points of sight simultaneously in the act of vision, though we may use one eye alone. Speaking generally, the eye wanders over any object we may be examining with slight pauses at each point of interest. Only at each pause do we really see, and our final mental impression of the whole object may be described as a mentally combined image of a series of "snap-shots." The retinal image produced at each "snapshot" is a perspective view with the node of the crystalline lens as the station point. The final mental picture is, however, a view with the centre of the eyeball (or its centre of rotation) as a station point. This latter view is smaller than the other, by reason of the fact that the centre of rotation is some little way behind the crystalline lens, hence the apparent size of an object varies as we study it. The general effect is further complicated by the lateral movement of the crystalline lens, which causes each momentary snapshot to be taken from a different station point; also the final impression is more or less influenced by the impression gained during the last fixed glance. Therefore we may conclude, with a considerable amount of reason, that we do not see objects exactly as they are. Really we only see a combination of a number of views taken from different points, and to arrive at a true understanding of what we see we must employ our capacity of reasoning. The extraordinary complexity of our mental visual conception is often deceptive, though unconsciously so to many people who have no idea of the peculiarities of vision.

The various effects of the employment of the two station points are not likely to be appreciated unless looked for, but once you realise the fact, evidence is easily collected. One of the most striking effects is the apparent movement of fixed points. In the experiment described by Mr. Betz the object point seems to play hide and seek with you, popping out from behind the screen when you look in another direction, and dodging back again when you try to look straight at it. It seems to move with the eye, but this effect is due mainly to the presence of the screen, for under other conditions it will generally be found that the apparent movement is opposite to that of the eye. The following experiment illustrates both the illusion of movement and also the dependence of apparent size upon the direction of vision.

Place two objects at different distances from the eye and subtending a moderate angle at the eye so that both can be seen when one is directly looked at. Look fixedly at one object and estimate the distance between the two. Then traverse the eye slowly on to the other object, and the distance between them most distinctly alters, the effect being apparently due to a shifting of one or both of the objects. You will find it somewhat puzzling to account for all the various effects of movement that can be detected under different conditions, but if you take all factors into consideration, you will, I think, eventually find that the shifting of the station point is primarily responsible for all the effects produced, other than those due to spherical aberration.

C. Welborne Piper.

May 15.

Mr. Piper's explanation of the curious phenomenon pointed out by Mr. Betz is presumably correct; that there are two station points used in vision can, however, scarcely be demonstrated. The positions of the nodal points of the eye are shifted during accommodation for near vision, and perhaps this displacement is what Mr. Piper refers to. In general it is difficult to observe the apparent motions of objects which Mr. Piper mentions, and it is still more difficult to trace such motions to the optical properties of the eye, since we are here dealing, not with optical images which can be directly examined, but with mental impressions. Thus König pointed out (*Wied. Ann.*, xxviii. pp. 367–368, 1886; "Gesammelte Abhandlungen zur physiologischen Optik," xiii. p. 58, Leipzig) that patients, on first being provided with strong divergent spectacles, complain that, on moving their eyes without turning their heads, stationary objects appear to move. After a time this apparent motion ceases to be observed, or, indeed, to be observable, but on removing the spectacles stationary objects appear to move in a sense opposite to that previously observed with the spectacles. In this case a readjustment of judgment respecting visual impressions has been effected; the result shows to what a great extent judgment enters into the act of vision.

Edwin Edser.

June 13.

School Geometry Reform.

In the unsigned review of Prof. Barrell's "Elementary Geometry" appearing in the issue of June 18, the following sentence occurs:—"A feature to be noticed is that the author gives three meanings of a plane angle, in the last of which the angle is regarded as the plane space swept out by a line of indefinite length (one way) turning about one end." It is unsafe to say that such a definition is wrong, but it is certainly most undesirable in a school book. The apprehension of the true nature of an angle is one of the greatest difficulties that the beginner has to encounter, and the way is not smoothed by the introduction of the idea of an infinitely extended space. It is true, as Mr. Russell points out ("Principles of Mathematics," p. 416), that the definition can be made logically satisfactory if the axiom of the whole, being greater than its part, be rejected; but this is an intolerable objection. The best course for an educational book is that adopted by Ronché and De Comberousse ("Traité de Geometrie," 1891, p. 5), who say:—"La considération de deux droites qui se rencontrent conduit à une idée nouvelle, qui est celle d'*inclinaison* mutuelle ou d'*angle*, et qui, comme l'idée de longueur, ne saurait être définie, c'est-à-dire ramenée à une idée plus simple."

R. W. H. T. Hudson.

June 22.

RECENT EXCAVATIONS AT NIPPUR.

It was in 1884, at a meeting of the American Oriental Society, that the first plans of an expedition to Southern Babylonia were projected, and from that year dates the beginning of the systematic scientific work which is being carried on by the Americans at the mounds of Nuffar, the ancient Nippur, with all possible thoroughness. Since the year 1888, there have been four expeditions sent out to excavate this ancient site, and there is still much to be done there. The first resulted in the discovery of a Parthian palace, and many "finds" from systematic diggings in the Temple of Bel, the cuneiform tablets alone numbering two thousand; but ill-luck overtook the members of the party, and, owing to trouble with the Arabs, the camp was burnt and they themselves were robbed. However, the next year, on reopening the works, there was no opposition, and the labours of the expedition were rewarded with eight thousand tablets of the second and third millennium B.C., and in the third campaign many pre-Sargonic ruins were discovered, besides more than twenty thousand tablets. The last expedition, which came to an end in 1900, was the most successful of all; the Parthian palace was completely explored, and, what was more important, the great library of the Temple of Bel was located, and twenty-three thousand clay tablets were excavated therefrom, thus bringing the total number found up to more than fifty thousand.

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Looking at the results of the four expeditions, we are struck with the careful way in which all operations have been conducted, especially towards the end of the period. The mounds were carefully surveyed, and even a relief map of them was made in plaster, the buildings which were discovered were accurately mapped, numerous photographs were taken of the various phases of the diggings, and as time went on those in command became even more methodical in their diggings. The manner in which the excavations were carried on merits the highest praise.

The "section" of the shafts dug through the mounds, as figured by Prof. Hilprecht in his latest work, "Explorations in Bible Lands" (p. 549), shows, as is common in ancient mounds, that the city was occupied from a very early period, and that from time to time new builders superimposed their pavements and dwellings upon those of an earlier period, so that the mounds are made up of successive layers, each marking an earlier building as the shafts sink lower. The diggers first cut through soil containing Sassanian and early Arabic remains. Then came the great Parthian fortress of the second or third century B.C. Next were found in six successive strata the pavements of buildings of (*a*) Ashurbanipal, who restored the great *ziggurat*, or temple-tower (*c*. 668-626 B.C.); (*b*) Kadashman-turgu (*c*. 1350 B.C.); (*c*) Ur-ninib (*c*. 2500 B.C.); (*d*) Ur-gur (*c*. 2700 B.C.); (*e*) Lugal-surzu (*c*. 3500 B.C.); (*f*) Sargon and Naram-Sin (*c*. 3750 B.C.). Below these, and beneath the level of the surrounding plain, a vaulted drain came to light, of a period distinctly before Sargon, and in the heart of the mound, on a slightly higher level, was a pre-Sargonic *ziggurat*. Straight down through these layers, from almost the top to the very water-level, a Parthian well had been sunk, a total distance of about seventy feet in depth. The mound of Nippur is therefore similar to Hissarlik and Tel-el-Hesy in the superimposition of cities.

The larger of the two Parthian buildings was a palace and fortress occupying what had been the centre part of the old Babylonian temple, and was an almost rectangular building surrounded by an enormous double wall, five hundred and sixty feet long on its south-eastern front. From the discovery of great masses of water-jars piled together in the southern part, as well as various fire-places and other kitchen arrangements close to them, it is clear that these were the servants' quarters, storehouses and bakeries. In the centre of the whole building rose the citadel, built over the ancient *ziggurat*, and it was through this that the only well of the whole building had been dug, evidently with the idea of the garrison holding out against a long protracted siege.

The smaller Parthian palace, west of the Chebar, which has been completely excavated, was a square building, measuring each side about 170 feet. It apparently had but one entrance, which was situated in the centre of the north-west façade. The walls varied in thickness from three to eight and a half feet, and the material used in the construction was brick, baked and unbaked. The roof, as the pieces of charred wood discovered in the ruins plainly show, was of palm logs, matting and earth. Prof. Hilprecht divides the building into two almost equal parts, the one for public functions and the other for the family life.

But important as these two buildings were, their interest cannot compare with the discoveries of earlier Babylonian ruins. Of these the huge *ziggurat*, or tower of the Temple of Bel, stands out pre-eminent, a huge brick building, the origin of which dates back to pre-Sargonic times, and shows in its various strata traces of the handiwork of the many kings who restored and added to it. According to Prof. Hilprecht, the Temple o Bel (called Ekur in the cuneiform inscriptions) was divided into two principal buildings, the *ziggurat* or great tower, and the "House of Bel." The whole was surrounded by the great wall called *Imgur-Marduk*. It is to this temple that the energies of the excavators have been principally directed, and from it have come the majority of the tablets found. The temple in Babylonia was not only a place wherein the gods might be worshipped, but was also a college at which priests were trained, and for this a reference library was essential. Consequently, it is not going too far to say that probably every important temple in Assyria and Babylonia had its own library of clay tablets. An excellent idea of what the temple rooms looked like may be gained from the photograph in Prof. Hilprecht's book, "Explorations in Bible Lands," p. 509.

In the remains of this Babylonian city many discoveries were made which add considerably to our knowledge of the daily life of the inhabitants. One of the most remarkable things found was a baking furnace made of brick, dating back to the third millennium B.C., composed of a series of seven (originally nine) parallel arches over a fire-box which ran lengthwise through the whole kiln. It was, in fact, very similar to the military field-ovens in use at the present day. Still earlier is the specimen of the elliptical arch which Haynes discovered, which Prof. Hilprecht assigns to the fifth millennium B.C. This is undoubtedly the first Babylonian arch known, and will go far to prove the much-disputed question of the origin of the arch.

Up to the present comparatively few of the tablets discovered in the ruins have been published, so that it is impossible to speak of the possibilities of the great temple library. We may notice, however, an important clay map of Nippur, photographed in Prof. Hilprecht's book (p. 518), which gives the environments of that ancient city as they were about two thousand five hundred years ago. Interesting, also, are the "practice" tablets, written by the pupils in the schools during their study of the Babylonian language. Indeed, it is to this class of tablet that we owe much of our knowledge of the classical works in cuneiform, for many similar are preserved in the British Museum which are inscribed with excerpts from the Creation legends, syllabaries, and incantations.

Much remains to be done at Nippur, and it is to be hoped that the Americans will continue and complete the great work they have begun. There is little doubt that when the mounds of Assyria and Babylonia have yielded up their hoards of cuneiform tablets stored up in the palace and temple libraries, our knowledge of those countries will equal, if not surpass, what we know of the archæology of Greece and Rome.

MATHEMATICAL REFORM AT CAMBRIDGE.

THE syndicate appointed in December, 1902, to consider what changes, if any, should be made in the regulations affecting the mathematical portions of the pass examinations of the University of Cambridge has recently presented a report which has just been adopted by the Senate, and will profoundly and beneficially affect the teaching of the subject in our public schools and throughout the country.

Recognising the widespread desire for reform, noting the changes that have already been made in the schedules of important examining bodies, and having examined the recommendations of various committees, the syndicate is convinced that changes are desirable, and that a "modification of the requirements of

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